APPENDIX A. INVESTIGATION AND POTENTIAL REMEDIAL ACTIONS FOR L-LAKE

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APPENDIX A. INVESTIGATION AND POTENTIAL REMEDIAL ACTIONS FOR L-LAKE

As discussed in Section 1.1, the U.S. Department of Energy (DOE) views potential future remedial actions regarding L-Lake and actions it might take in the near term regarding operation of the River Water System to be connected actions. The purpose of this environmental impact statement (EIS) is to assist DOE in making a decision in 1997 on the operation of the River Water System that could change the current status of L-Lake with respect to such parameters as water levels and associated potential risks from exposure to contaminated lakebed sediments.

DOE has initiated discussions with EPA and SCDHEC to ensure appropriate consistency and coordination is maintained between this operation decision and remedial decisions for L-Lake. L10-04 Remedial decisions for the lake will be in accordance with the process set forth in the Federal Facility Agreement (FFA; EPA 1993), which provides the appropriate framework for planning site remediations. L10-04

The DOE Office of National Environmental Policy Act (NEPA) Policy and Assistance has provided recommendations regarding the appropriate way to address such connected actions in its NEPA documents (DOE 1993). In accordance with these recommendations, DOE describes in this EIS (Section 4.5) the cumulative impacts of the Proposed Action and potential remedial actions regarding L-Lake that could result from the FFA process, but is deferring any analysis of remedial action alternatives until they are ready for consideration.

This appendix supports the cumulative impacts discussion in Section 4.5 by describing potential future remedial actions that DOE could take under the FFA with respect to L-Lake.

A.1 Current and Potential Future Status of L-Lake Under the Federal Facility Agreement

As discussed in Section 5.5, DOE has entered into an FFA with the U.S. Environmental Protection Agency (EPA) and the South Carolina Department of Health and Environmental Control (SCDHEC) in accordance with Section 120 of the Comprehensive Environmental Response, TE Compensation, and Liability Act (CERCLA). This agreement establishes the process DOE uses to evaluate actually or potentially contaminated sites at the Savannah River Site (SRS) and, if necessary, to remediate contaminated sites with appropriate consideration of the potential risks they pose to human health and the environment.

In general, newly discovered sites and other sites that merit preliminary evaluation are designated as Site Evaluation units and are listed in Appendix G.1 of the FFA. These sites receive formal site evaluations that rely primarily on existing and available information; field investigations conducted during this phase are normally limited in scope. Results of a site evaluation can provide the basis for no further action, near-term actions to reduce or eliminate an actual or potential threat (i.e., a removal action), or a decision to list the unit in Appendix C of the FFA for further evaluation. L-Lake is currently listed as a Site Evaluation unit in Appendix G.1 of the FFA.

Sites listed in Appendix C, called Resource Conservation and Recovery Act (RCRA)/ CERCLA units, are subject to the remedial action process established in the FFA. This process generally includes detailed RCRA Facility Investigation/Remedial Investigation (RFI/RI) studies to determine the nature and extent of contamination, a baseline risk assessment to determine the risk posed by the contamination and, if necessary, remedial actions selected on the basis of a formal Corrective Measures Study/Feasibility Study (CMS/FS), which includes a rigorous alternatives analysis. Public comments on the proposed remedial alternative will be facilitated with a Statement of Basis/Proposed Plan. The RCRA permit modification and Record of Decision provide the final documentation of the selection of remedial alternative and response to public comment.

The RCRA/CERCLA units listed in Appendix C of the FFA include contaminated stream systems on the SRS. These systems are termed Integrator Operable Units (IOUs) in recognition of the need to consider multiple sources of contamination in their watersheds as part of the remedial action process for these streams. In view of this peculiarity, the scope of the remedial action strategy for an IOU is more similar in scope to a long-term site evaluation than the traditional remedial action process applied to individual RCRA/CERCLA units, as described above. The Steel Creek stream channel and floodplain above, below, and beneath the L-Lake impoundment are among the IOUs listed in Appendix C. Investigations to determine the nature and extent of contamination and studies to determine appropriate remedial actions for the Steel Creek watershed will be conducted in accordance with the FFA.

DOE had originally planned to complete a Site Evaluation Report for L-Lake by December 1996. This report was being prepared in accordance with the FFA to determine the need for additional future investigations and identify any
L10-01 removal actions that may be appropriate for this unit and to help determine the appropriate relationship of this unit to the Steel Creek IOU. However, in response to EPA's comments on the Draft EIS, DOE believes that sufficient information is presented in this Appendix to accomplish these objectives without completing
L10-01 the final Site Evaluation Report.

Existing information indicates that the stream channel and floodplain of Steel Creek upstream, downstream, and within L-Lake are contaminated by radionuclides, primarily cesium-137 but also cobalt-60, as a result of discharges from reactor operations before the construction of the impoundment. In some locations, low level of this contamination extends to lakebed sediments beyond the original stream channel and floodplain. If DOE implements the Proposed Action considered in this EIS, L-Lake would be dewatered, ultimately restoring Steel Creek and its floodplain to conditions similar to those existing before its impoundment and exposing these contaminated sediments.

As noted above, DOE believes that sufficient information to make ultimate remedial decisions
TE for L-Lake will not be available until required studies under the FFA are complete. Therefore, DOE undertook a specific study (PRC 1996, 1997a, 1997b, 1997c) to identify and evaluate the likely range of remedial action alternatives
TE that it might ultimately consider under the FFA. A particular objective of the study is to make a preliminary estimate of potential remediation costs for various alternatives to control risks from exposure to contaminated sediments within the lake exclusive of the Steel Creek stream channel and floodplain. (DOE would evaluate and, if appropriate, propose remediation of the stream channel and floodplain as part of the Steel Creek IOU.) The remedial alterna-
TC tives study, which was conducted to help guide DOE economic decisions associated with the River Water System in the near term, is summarized in Section A.2, based on the initial study report (PRC 1996) and subsequent analy-
TE sis revisions (PRC 1997a, 1997b, 1997c).

A.2 Range of Remedial Options for L-Lake

The DOE study of potential remedial options and associated costs for L-Lake (PRC 1996, 1997a, 1997b, 1997c) uses historic process knowledge about contaminant release mechanisms and L-Lake development, and results of past and ongoing sampling activities to estimate the nature and extent of contamination in lake sediments. Remedial goal options (RGOs), expressed as sediment contaminant concentrations corresponding to target risk levels, were established using hypothetical exposure scenarios. Based on this information, spatial distribution of contamination in lake bottom sediments above RGOs was delineated. Finally, remedial action options likely to be able to meet preliminary remedial action goals were identified and evaluated with respect to cost and other relevant factors, as described in Section A.2.4. The following subsections summarize these elements of the study.

A.2.1 GENERAL NATURE AND EXTENT OF L-LAKE SEDIMENT CONTAMINATION

Detailed information on the nature and extent of contamination to support final remedial decisions will be developed in the context of the FFA. However, sufficient information is available from historic process knowledge and from past and ongoing sampling activities to examine a range of potential remedial options for L-Lake. This information indicates that the contaminants of most concern in the lake sediments are radionuclides, particularly cesium-137 and to a lesser extent cobalt-60, which are the focus of the potential remedial options study (PRC 1996, 1997a, 1997b).

Radionuclide contamination of Steel Creek is primarily from purge water discharges from disassembly basins containing fuel elements at P-Reactor and L-Reactor before this practice was discontinued in the early 1970s (DOE 1984). The large flow of the cooling water discharge containing the purge water raised the stream level consistent with the floodplain, so contaminants from the purge water tended to be deposited in both the stream channel and the floodplain. Radioactivity release reports suggest that most of these contaminant releases occurred before 1971; only minimal releases have occurred since the formation of L-Lake in 1985. Cesium-137 has a strong affinity for sediments, so the majority of this contaminant was adsorbed or deposited in the sediments of the 11.2-mile (18.0-kilometer) Steel Creek system before reaching the Savannah River. Based on DOE sponsored studies cited by PRC (1996), the estimated cesium-137 inventory in the entire creek system from upstream of L-Reactor to the Savannah River, including L-Lake, is 58 curies (decay corrected to 1996).

DOE has conducted extensive investigations of the L-Lake vicinity using a variety of sampling and analysis techniques. Data from a preimpoundment aerial radiological survey of the L-Lake vicinity conducted in 1985 indicated that the contamination zone for cesium-137 and cobalt-60 corresponded to the historic stream channel and floodplain. Another aerial radiological survey conducted in 1986 after the impoundment of L-Lake indicated only minor changes from the previous year in the spatial distribution of these contaminants upstream and downstream from L-Lake. This technique could not obtain data for submerged areas of L-Lake.

DOE conducted underwater gamma surveys in 1995 and 1996 to identify any post-impoundment changes in the distribution of manmade radiation levels in L-Lake. The 1995 study included *in situ* measurements from 96 locations on the lake bottom and laboratory analysis results from sediment samples from 20 locations. The 1996 study involved the use of approximately 195 *in situ* measurement locations and 76 sediment sample locations. The results from these surveys indicted no major change in manmade radionuclide distributions since radiological mapping of the lake basin in 1985, though minor differences are apparent.

Additional samples of lake bottom sediments were obtained and analyzed in 1995 and 1996. Analytical results for samples obtained in 1995, consisting of sediment samples from eight locations including the submerged stream channel and floodplain, indicate that organic contaminants are well below EPA Region IV risk-based concentrations used as screening levels at the SRS.

In the summer of 1996 surface sediment samples (0 to 1 foot) (0 to 0.3 meter) were collected from approximately 45 locations in the lake (including the stream channel and floodplain) and 13 background locations for analysis of toxic metals, gross alpha, nonvolatile beta, gamma pulse height analysis, plutonium-alpha series, and uranium-alpha series (Phase 1 sampling). Analysis of validated data from this
L9-16 sampling effort indicates that low concentrations of radionuclide contamination are present in the lakebed outside of the original stream channel and floodplain (PRC 1996, 1997b). Analysis of these data also indicates that some toxic metals are present at low concentrations in the lake. Later in 1996, DOE collected lake sediment core samples from additional 22 selected locations in L-Lake (Phase 2 sampling).

TC DOE used analytical results from the summer of 1996 sampling to identify areas of the lake bottom that could present a risk above target levels under assumed exposure scenarios. The results were used in combination with the 1996 underwater gamma survey data as the basis for the potential remedial options study (PRC 1996). Subsequent analyses reported by PRC (1997a, 1997b, 1997c) also used validated radionuclide analysis results from the 0 to 1 foot (0 to 0.3 meter) level in cores obtained during the
L9-19 Phase 2 sampling. The updated options analysis based on these analyses is summarized in this appendix. The location of data points in L-Lake upon which the study is based are shown in Figure A-1.

A.2.2 PRELIMINARY REMEDIAL GOAL OPTIONS AND SCREENING VALUES

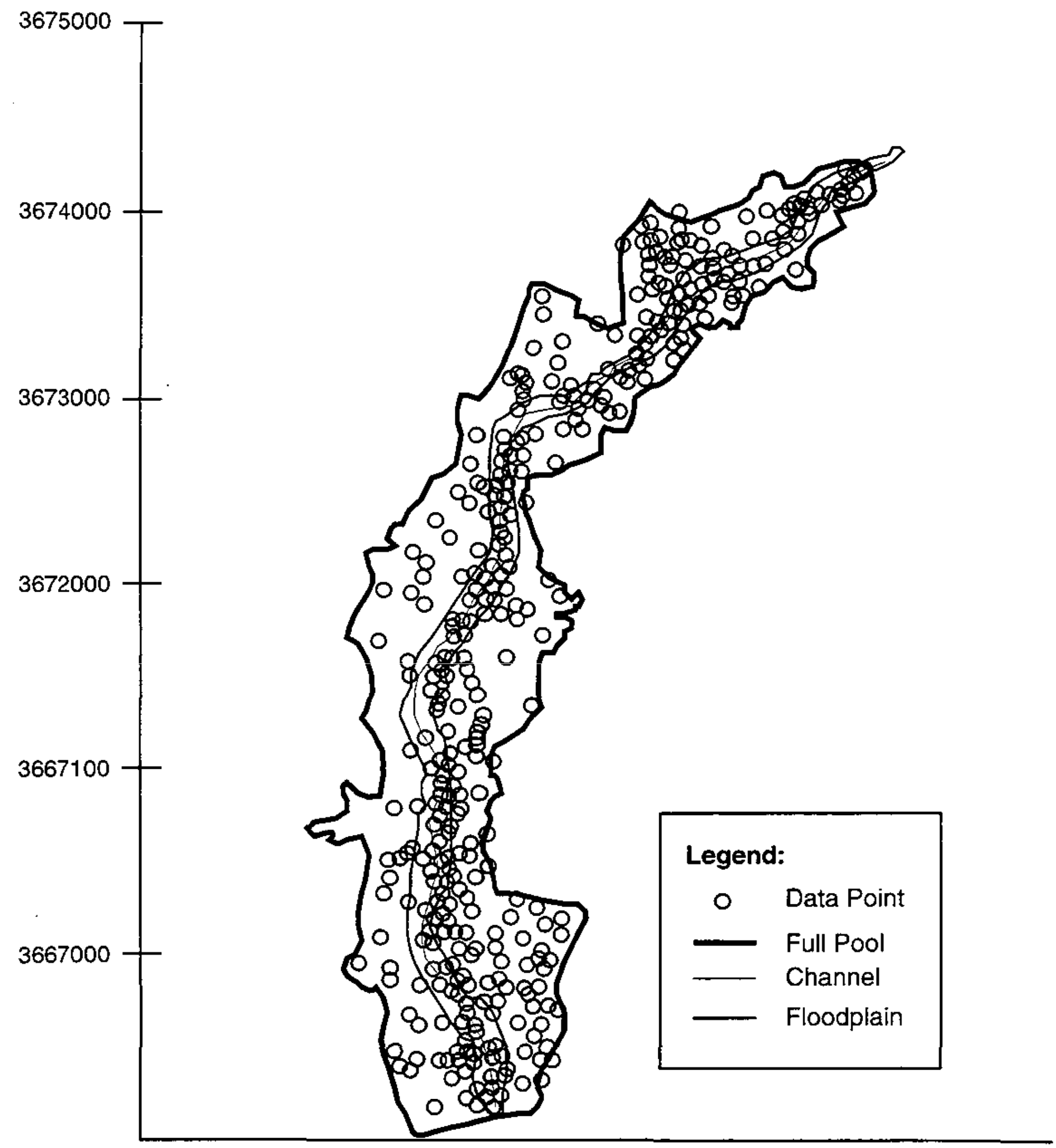
For comparison purposes, the potential remedial options study considered two exposure scenarios, current/future onsite worker and hypothetical future resident. Screening values for sediment contaminant concentrations were derived for each scenario.

TE For the Draft EIS, DOE developed the onsite worker exposure scenario and associated exposure parameter values using the information from EPA's Hazardous Waste Remedial Action Program (HAZWRAP 1996) with input from the Savannah River Technology Center (SRTC) at the SRS. DOE used best professional judgment, knowledge of the types of activities that occur at the SRS, and the likely parameters these activities would generate in place of standard EPA default values (i.e., EPA 1991).

This onsite worker exposure scenario was revised for the Final EIS to reflect a more realistic exposure assessment for an environmental researcher or sampler than that reflected in HAZWRAP (1996). The current scenario assumes that an environmental researcher or sampler is present in the L-Lake vicinity for 5 years, 15 weeks per year, and 6 hours per
TC week. This scenario is consistent with that used in Section 4.1.8.2 of this EIS.

Exposure routes considered for the onsite worker scenario were inhalation of resuspended particulates from dried lake basin sediments and ingestion, dermal exposure, and external exposure attributable to direct contact with soil and sediment in the lake basin.

The screening values for the hypothetical onsite resident exposure scenario were determined using risk-based assessment methods developed by the EPA. The scenario assumes a human population living and working in the contaminated area for as long as 30 years. Exposure assumptions include incidental soil ingestion, direct radiation, and inhalation of contaminated particulates.



Source: PRC (1997b)

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Figure A-1. Data points used for L-Lake remedial options analysis.

L9-19

Screening values for both cesium-137 and cobalt-60 were derived from these risk analyses for each scenario at two risk levels: 10^{-4} (i.e., one additional estimated cancer per 10,000 exposed persons) and 10^{-6} (i.e., one additional estimated cancer per 1 million exposed persons). These screening values, listed in Table A-1, do not take credit for radioactive decay or a period of institutional control (i.e., uncontrolled exposure is assumed to begin immediately). These are conservative assumptions considering DOE's anticipated nonresidential use of the site and the half-life of these radionuclides (30 years for cesium-137 and 5.24 years for cobalt-60).

Overall, these screening values are conservative (i.e., low). This conservatism is particularly indicated by the screening concentration for cesium-137 corresponding to the 10^{-6} risk level for the residential scenario (0.02 picocurie per gram), which is well below the average concentration of 0.09 picocurie per gram observed in the 13 background soil samples obtained in the summer of 1996.

Assuming a 30-year period of institutional control and accounting for radioactive decay would increase the screening values in Table A-1 by a factor of 2.7 for cesium-137 and a factor of 200 for cobalt-60. However, DOE used the lower values for this remedial options analysis because EPA Region IV and SCDHEC have not endorsed the use of radiological decay and institutional control in risk analyses performed under the FFA. For similar reasons, DOE did not establish screening values for this remedial options analysis based on its current SRS worker limits (700 millirem per year) and limits to the general public (100 millirem per year), or a 15-millirem-per-year cleanup standard for unrestricted (i.e., residential) use being considered by DOE and EPA, all of which would result in higher screening values and less stringent cleanup goals.

Only those screening values listed in bold type in Table A-1 were selected as preliminary RGOs for the options analysis (PRC 1996). TC DOE dropped cobalt-60 values because sampling data indicate that cobalt-60, where it exceeds screening values, is colocated with cesium-137 in excess of screening values, and cesium-137 has a longer half-life than cobalt-60 (30 years versus 5.24 years). Similarly, the use of cesium-137 screening values was assumed to adequately accommodate the low levels of toxic L9-16 metals that exist in lake sediments based on analysis of validated data observed in the lake; no organic contaminants have been noted above screening levels (Section A.2.1). Cesium-137 was thus considered to be the primary "risk driver" for the analysis.

Table A-1. Risk-based screening values for cesium-137 and cobalt-60 in L-Lake sediments.

	Sediment concentration (picocuries per gram)[a]			
	Onsite worker scenario		Future onsite resident scenario	
Contaminant	Risk = 10^{-4}	Risk = 10^{-6}	Risk = 10^{-4}	Risk = 10^{-6}
Cesium-137	**930**	**9.3**	**2.1**	**0.021**
Cobalt-60	100	2.7	0.48	0.0048

a. Values in bold denote remedial goal options.

A.2.3 DELINEATION OF CONTAMINATION ZONES CORRESPONDING TO REMEDIAL GOAL OPTIONS

Assuming that some form of action or remediation would be required if a cesium-137 RGO was exceeded, areas of lake-bottom sediment contamination corresponding to the four selected RGO values (i.e., bold values in Table A-1) were delineated on the basis of sampling and survey data as described in Section A.2.1. Figure A-2 shows the results. As shown, no cesium-137 sediment concentrations exceeded 930 picocuries per gram, indicating that no remedial action would be necessary under an onsite worker scenario at the 10^{-4} risk level. Similarly, the analysis indicates that only a very small area (perhaps 1 acre) outside of the Steel Creek channel and floodplain may require remediation, assuming the onsite worker scenario at the 10^{-6} risk level.

At the other extreme, approximately 750 acres (3.0 square kilometers) comprised of virtually all the lake bottom except the area occupied by the inundated Steel Creek channel and floodplain would require remediation to protect onsite residents at the 10^{-6} risk level. This would not be a realistic option, since background concentrations are above the 10^{-6} risk level as well.

For the intermediate scenario, which assumes protection of future residents at the 10^{-4} risk level, an estimated 170 acres (0.69 square kilometer) of the lake bottom, except the currently inundated stream channel and floodplain, would require remediation (Figure A-2).

The inundated stream channel and floodplain, which occupies about 170 acres (0.69 square kilometer) of the lake bottom, is not part of the area considered for the remedial options analysis (PRC 1996) because corresponding areas above, below, and beneath L-Lake exhibit radiological contamination above risk-based screening levels and are part of the Steel Creek watershed IOU. In addition, any remedial actions determined under the FFA for the Steel Creek IOU would necessarily include that portion of the creek and floodplain currently occupied by L-Lake.

A.2.4 DESCRIPTION OF REMEDIAL OPTIONS

DOE evaluated four remedial options for areas of the former lake bottom considered to be contaminated under the risk scenarios considered in the analysis, as follows:

- Option 1 - No Action
- Option 2 - Institutional Control
- Option 3 - Soil Cover
- Option 4 - Excavation and Disposal of Contaminated Soil

These options were the most reasonable within the range of possible alternatives based on professional judgment, knowledge of SRS activities, and prior experience obtained as a result of detailed feasibility studies completed for two SRS waste sites where similar remedial alternatives were considered.

<u>No-Action Option</u>

Under the no-action remedial option, DOE would take no action to address contamination of exposed L-Lake sediments; to monitor, remove, treat, or otherwise mitigate this contamination under any of the identified risk scenarios; or to minimize the threat or potential threat to human health and the environment.

<u>Institutional Control Option</u>

The institutional controls determined to be most applicable to areas of contaminated sediments exposed in L-Lake and thus assumed for the alternatives analysis consist of existing SRS access controls to maintain the SRS industrial use; deed notifications and, if appropriate, deed restrictions in the event the property is transferred to non-Federal ownership; and posting of warning signs. It was assumed that during the

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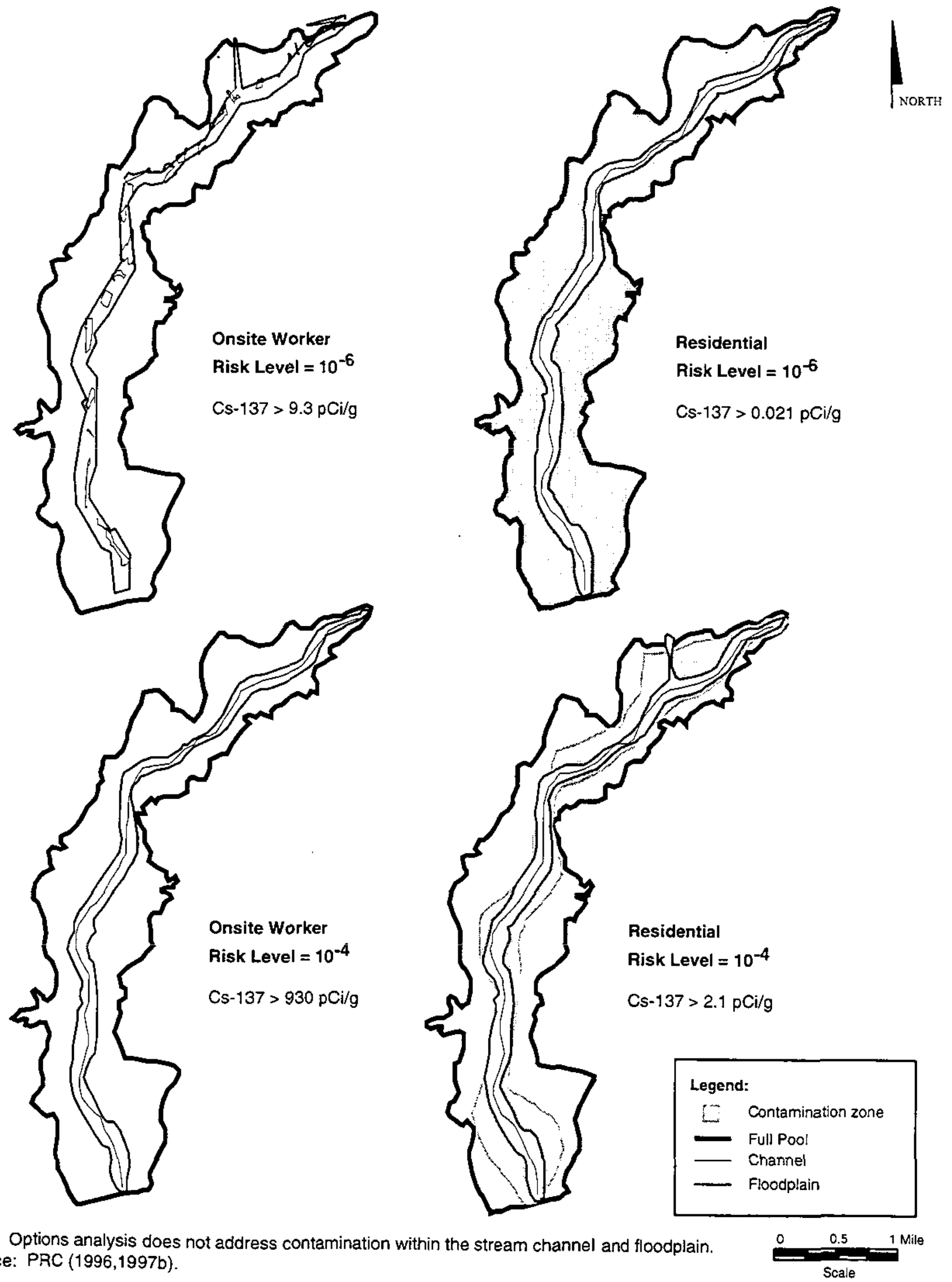

Note: Options analysis does not address contamination within the stream channel and floodplain.
Source: PRC (1996,1997b).

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Figure A-2. Assumed contamination zones for L-Lake remedial options analysis.

period of DOE control, such existing access controls as barriers, fences, and controlled areas would be used to maintain the SRS for industrial use. If the property is transferred to non-Federal ownership, the U.S. Government would, in accordance with CERCLA Section 120(h), create a deed that includes notification in perpetuity of the contamination. It was also assumed that a survey plat of L-Lake prepared by a professional land surveyor would be placed in the county records. In addition to the notification, a deed restriction to preclude residential use of the property may also be utilized when and if the area was to be transferred to private ownership. Warning signs would be posted at all roads intersecting the contaminated zone.

<u>Soil Cover Option</u>

The soil cover option considered most appropriate for this site consists of a native soil cover; vegetative cover for erosion control; short-term institutional controls to limit worker exposure during drawdown and in the long term to ensure designated land use, prevent excavation and shallow wells, etc.; 30 years of inspection and maintenance; and reviews of the remedy with regulators at 5-year intervals for 30 years. The primary purpose of the barrier would be to limit exposure to gamma radiation associated with the radionuclide contaminants present. The extent and thickness of needed soil cover would depend on the scenario considered. None would be required for the onsite worker (10^{-4} risk) scenario. A 1-foot (0.3-meter) thick cover over approximately 1 acre (4,000 square meters) would be used for the worker (10^{-6} risk) scenario and a 4-foot (1.2-meter) thick cover over 750 acres (3.0 square kilometers) or 170 acres (0.69 square kilometers) would be used for the resident (10^{-6} risk) and resident (10^{-4} risk) scenarios, respectively. Deed notifications may be effected to restrict a small area to industrial use under the worker (10^{-6} risk) scenario and would be effected to prevent deep excavation and installation of shallow wells under both resident scenarios.

<u>Soil Excavation and Disposal Option</u>

The option of excavation and disposal of contaminated soil would involve the removal of contaminated soil with conventional earthmoving equipment to a depth of 2 feet (0.6 meter) over approximately 1 acre (4,000 square meters) for the onsite worker scenario at the 10^{-6} risk level, or 3 feet (0.9 meter) over 750 acres (3.0 square kilometers) or 170 acres (0.69 square kilometers) depending on the resident scenario analyzed (10^{-6} risk and 10^{-4} risk, respectively). The assumptions for excavation depth are based on information collected during construction of the L-Lake Dam, which indicate that the approximate depth of the 1.1 picocuries per gram contour is 24 inches (61 centimeters) (PRC 1996). Existing SRS disposal facilities are not designed to manage large quantities of contaminated soil; therefore, the analysis assumes that the contaminated soil would be disposed of at a licensed offsite facility (e.g., the Chemical Waste Management Facility, Emile, Alabama; the Envirocare Facility, Clive, Utah). Excavated areas would be filled with clean soil and revegetated.

A.2.5 EVALUATION OF REMEDIAL OPTIONS

DOE used methods similar to those that would be conducted in a CERCLA feasibility study under the FFA (see Section 5.5) to evaluate remedial options. DOE used the following six (of the nine) CERCLA criteria normally used for such evaluations:

- Overall protection of human health and the environment
- Cost
- Implementability
- Short-term effectiveness
- Long-term effectiveness
- Reduction of contaminant toxicity, mobility, and volume

Compliance with state and Federal regulations, one of the three criteria that was not used, was assumed to be achieved, or appropriate waivers obtained, regardless of the remedial action selected. The two remaining criteria, state agency acceptance and community acceptance, are modifying criteria in the development of a preferred alternative under the CERCLA process and were not considered appropriate to the NEPA remedial options analysis.

Results of the evaluation with respect to the six selected criteria are described below.

- No Action (Table A-2) – The no-action option is clearly the remedial option of choice with respect to the onsite worker (10^{-4} risk) scenario because none of the L-Lake sediment contamination exceeds the remedial goal option of 930 picocuries per gram. However, this option would not protect onsite workers at the 10^{-6} risk level, at least within a small area, or future residents at either the 10^{-4} or 10^{-6} risk levels because DOE would take no action to reduce risk posed by contaminated sediments. Existing radiological contamination is at levels that would result in doses significantly below the 1-rad-per-day threshold commonly cited for ecological receptors. As with all remedial options considered, no reduction of

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Table A-2. L-Lake remedial options analysis evaluation criteria ratings for the no-action option.

Evaluation criteria	Onsite worker (Risk = 10^{-4})	Onsite worker (Risk = 10^{-6})	Future resident (Risk = 10^{-4})	Future resident (Risk = 10^{-6})
Overall protection of human health and environment	Good – No contamination above 930 picocuries -per-gram RGO.[a]	Moderate – Not protective at 9.3-picocuries-per-gram RGO but in only a small area [approximately 1 acre (4,000 square meters)].	Poor – Not protective at 2.1-picocuries-per-gram RGO.	Poor - Not protective at 0.021-picocurie-per-gram RGO.
Cost	Good - No cost.	Good - No cost.	Good - No cost.	Good - No cost.
Implementability	Good - No active remediation needed.	Good - No active remediation.	Good - No active remediation.	Good - No active remediation.
Short-term effectiveness	Good - No risk above RGO.	Moderate - No short-term protection of workers at 9.3-picocuries-per-gram RGO, but in only a small area, and no construction activities and associated impacts.	Moderate - Existing land use controls limit access. No construction activities and associated impacts.	Moderate - Existing land use controls limit access. No construction activities and associated impacts.
Long-term effectiveness	Good - No risk above RGO.	Moderate - No effort to mitigate exposure to contaminated sediments, but they are confined to a small area, and natural decay would reduce radiological risk.	Poor - No effort to mitigate exposure to contaminated sediments, but natural decay would reduce radiological risk.	Poor - No effort to mitigate exposure to contaminated sediments, but natural decay would reduce radiological risk.
Reduction of contaminant toxicity, mobility, and volume	NA[b]	Poor - No active remediation.	Poor - No active remediation.	Poor - No active remediation.

TC

a. RGO = Remedial goal option.
b. NA = Not applicable.

contaminant toxicity, mobility, or volume would be effected, but overall risk would be reduced by radioactive decay of the cesium-137 (half-life = 30 years), which would reach background levels in approximately 100 years.

Institutional Control (Table A-3) – Institutional control, consisting primarily of SRS security measures, sign postings, deed notifications and, if appropriate, restrictions, would be inexpensive and readily implemented under all scenarios. This remedial option is rated as having good effectiveness in the short term and as moderate with respect to long-term effectiveness and overall protection of human health under the onsite worker (10^{-6} risk) and both future resident scenarios.

Table A-3. L-Lake remedial options analysis evaluation criteria ratings for the institutional control option.

Evaluation criteria	Onsite worker (Risk = 10^{-4})	Onsite worker (Risk = 10^{-6})	Future resident (Risk = 10^{-4})	Future resident (Risk = 10^{-6})
Overall protection of human health and environment	NA[a]	Moderate - If controls were not observed, risk to worker would exceed 10^{-6} for approximately 1 acre along the floodplain. Natural decay would reduce radiological risk.	Moderate - Land would be restricted to industrial use. Effective as long as warning signs and security measures are maintained and deed restrictions are enforced. If controls are not observed, risk to residents would exceed 10^{-4}. Natural decay would reduce radiological risk.	Moderate - Land would be restricted to industrial use. Effective as long as warning signs and security measures are maintained and deed restrictions are enforced. If controls are not observed, risk to residents would exceed 10^{-6}. Natural decay would reduce radiological risk.
Cost	NA	Good - $10,000 for sign placement and deed notification costs.	Good - $15,000 for sign placement and deed notification costs.	Good - $15,000 for sign placement and deed notification costs.
Implementability	NA	Good - No active remediation.	Good - No active remediation.	Good - No active remediation.
Short-term effectiveness	NA	Good - Worker exposure would be limited. No construction activities necessary for implementation.	Good - Land use controls would limit access. No construction activities necessary for implementation.	Good - Land use controls would limit access. No construction activities necessary for implementation.
Long-term effectiveness	NA	Moderate - Effective as long as warning signs and security measures are maintained and land use controls are observed. Natural decay would reduce radiological risk.	Moderate - Effective as long as warning signs and security measures are maintained and land use controls are observed. Natural decay would reduce radiological risk.	Moderate - Effective as long as warning signs and security measures are maintained and land use controls are observed. Natural decay would reduce radiological risk.
Reduction of contaminant toxicity, mobility, and volume	NA	Poor - No active remediation.	Poor - No active remediation.	Poor - No active remediation.

a. NA = Not applicable.

- Soil Cover (Table A-4) – This option is rated good in terms of overall protection of human health for both onsite workers (10^{-6} risk level) and future residents (10^{-4} and 10^{-6} risk levels) assuming cover is maintained and land use controls are observed. It would not be as readily implementable or as effective in the short-term under the 10^{-6} risk future resident scenario because of the additional soil cover required [1 foot versus 4 feet (0.3 meter versus 1.2 meters)] compared to the 10^{-6} risk worker scenario and the additional time required to install the cover [e.g., 1 year versus 5 years after the 10-year lake drawdown period (Jones and Lamarre 1994)]. This option would be expensive to implement for the future resident scenario (estimated costs of approximately $30 to $131 million, depending on risk level).

- Soil Excavation and Offsite Disposal (Table A-5) – This option is rated good in terms of overall protection of human health and the environment and long-term effectiveness for onsite worker (10^{-6} risk level) and future resident scenarios because all contaminated soils above the respective RGOs would be removed. However, short-term effectiveness is rated poor for both future resident scenarios because of the long construction periods required [13 years and 55 years based on the capability to move 180 cubic yards (138 cubic meters) per day (PRC 1996)], increased probability of worker injuries or fatalities, and adverse effects from the transportation of large amounts of contaminated soils to an offsite disposal facility.

  Implementability is rated good for the onsite worker (10^{-6} risk) but poor for the future resident scenarios, because of the large amount of soil excavation and disposal required. Cost for this alternative would be very high for either of the future resident scenarios ($380 million or $1.7 billion, depending on risk level).

A.2.6 CONCLUSIONS

The preliminary analysis summarized in Section A.2 indicates that remedial options to reduce risk posed by contaminated lakebed sediments above the Steel Creek stream channel and floodplain may range from no action to very intensive remediation involving removal and offsite disposal of contaminated soils.

Based on the evaluations presented in this analysis, DOE believes that institutional controls to prevent residential use of this area for a period that allows for natural radiological decay to safe levels may be the most reasonable option. No action may be necessary to protect workers at the 10^{-4} risk level. In addition, this preliminary analysis indicates that onsite worker exposure levels would be well below the current SRS occupational standard for radiation protection of 700 millirem per year, which corresponds to a cesium-137 concentration of approximately 1,962 picocuries per gram (compared to 9.3 picocuries per gram of cesium-137 for the onsite worker scenario at 10^{-6} risk). If the cleanup standard for unrestricted use (residential scenario) of 15 millirem per year proposed by EPA and DOE was promulgated, no remedial action for this area may be necessary. An annual effective dose equivalent of 15 millirem corresponds to approximately 9 picocuries per gram for cesium-137 and an average excess lifetime carcinogenic risk of approximately 3×10^{-4}. Moreover, natural decay would reduce cesium-137 to near background levels in 100 years.

Table A-4. L-Lake remedial options analysis evaluation criteria ratings for the soil cover option.

Evaluation criteria	Onsite worker (Risk = 10^{-4})	Onsite worker (Risk = 10^{-6})	Future resident (Risk = 10^{-4})	Future resident (Risk = 10^{-6})
Overall protection of human health	NA[a]	Good - Cover and observance of land use controls would prevent direct exposure. Natural decay would reduce radiological risk.	Good - Cover and observance of land use controls would prevent direct exposure. Natural decay would reduce radiological risk.	Good - Cover and observance of land use controls would prevent direct exposure. Natural decay would reduce radiological risk.
Cost	NA	Moderate - $100,000 cost of filling plus inspection and maintenance costs.	Poor - $29.7 million (29.6 million cubic feet at $1 per cubic foot plus inspection and maintenance costs).	Poor - $131 million (130.7 million cubic feet at $1 per cubic foot plus inspection and maintenance costs).
Implementability	NA	Good - Equipment and materials could be readily obtained. Cover could be installed in 1 year.	Moderate - Equipment and materials could be readily obtained but quantity of soil required would be very large and would require 1 year or more to install.	Moderate - Equipment and materials could be obtained readily, but quantity of soil required would be very large and would require as long as 5 years to install.
Short-term effectiveness	NA	Moderate - Reliance on institutional controls during drawdown period but contamination is limited to approximately 1 acre near floodplain. Protective equipment and other controls would be required to protect workers during construction period (less than 1 year).	Moderate - Reliance on institutional controls during drawdown period. Protective equipment and other controls would be required to protect workers during 1-year construction period.	Poor - Reliance on institutional controls during drawdown period. Protective equipment and other controls would be required to protect workers during 5-year construction period. TC
Long-term effectiveness	NA	Moderate - Effective as long as land use controls are observed and cover is maintained. Natural decay would reduce radiological risk.	Moderate - Effective as long as land use controls are observed and cover is maintained. Natural decay would reduce radiological risk.	Moderate - Effective as long as land use controls are observed and cover is maintained. Natural decay would reduce radiological risk.
Reduction of contaminant toxicity, mobility, and volume	NA	Poor - Airborne dust would be reduced, but no other reductions would be effected. However, natural decay would reduce cesium-137 concentrations to background in approximately 100 years.	Poor - Airborne dust would be reduced, but no other reductions would be effected. However, natural decay would reduce cesium-137 concentrations to background in approximately 100 years.	Poor - Airborne dust would be reduced, but no other reductions would be effected. However, natural decay would reduce cesium-137 concentrations to background in approximately 100 years.

a. NA = Not applicable.

Table A-5. L-Lake remedial options analysis evaluation criteria ratings for the soil excavation and off-site disposal option.

Evaluation criteria	Onsite worker (Risk = 10^{-4})	Onsite worker (Risk = 10^{-6})	Future resident (Risk = 10^{-4})	Future resident (Risk = 10^{-6})
Overall protection of human health and environment	NA[a]	Good - Complete protection of onsite worker after soils contaminated above 9.3 picocuries per gram of cesium-137 are removed and backfilling and regrading with clean soil was complete.	Good - Complete protection of onsite worker after soils contaminated above 2.1 picocuries per gram of cesium-137 are removed and backfilling and regrading with clean soil was complete.	Good - Complete protection of human health and environment after soils contaminated above approximate background concentrations of cesium-137 were removed and backfilling and regrading with clean soil was complete.
Cost	NA	Moderate - Approximately $1.4 million exclusive of transportation costs.	Poor - Approximately $380 million exclusive of transportation costs (22.2 million cubic feet at $0.80 per cubic foot for excavation, regrading, plus $16.30 per cubic foot for disposal; 7.4 million square feet at $0.20 per square foot for revegetation).	Poor - Approximately $1.7 billion exclusive of transportation costs (98 million cubic feet at $0.80 per cubic foot for excavation, regrading plus $16.30 per cubic foot for disposal; 32.7 million square foot at $0.20 per square foot for revegetation).
Implementability	NA	Good - Equipment and materials could be obtained but would take approximately 1 year to implement.	Moderate - Equipment and materials could be obtained but would take up to 13 years to implement.	Poor - Equipment and materials could be obtained readily, but quantity of soil required would be large and would require as long as 55 years to implement.
TC Short-term effectiveness	NA	Moderate - Requires institutional controls during drawdown period but contamination is limited to approximately 1 acre near floodplain. Protective equipment and other controls would be required to protect workers during 1-year construction period. Some risk to public and environment during transportation.	Poor - Requires institutional controls during drawdown period. Protective equipment and other controls would protect workers but likelihood of injury or fatality during 13-year construction period would be high. Some risk to public and environment during transportation.	Poor - Requires institutional controls during drawdown period. Protective equipment and other controls would protect workers but likelihood of injury or fatality during 55-year construction period would be high. Some risk to public and environment during transportation.
Long-term effectiveness	NA	Good - Contaminated materials above 9.3 picocuries per gram of cesium-137 would be removed and replaced by clean fill.	Good - Contaminated materials above 2.1 picocuries per gram of cesium-137 would be removed and replaced by clean fill.	Good - Contaminated materials above approximate background concentrations of cesium-137 would be removed and replaced by clean fill.
Reduction of contaminant toxicity, mobility, and volume	NA	Poor - No treatment to reduce toxicity, mobility, or volume, although natural decay of cesium-137 would reduce concentrations to background in approximately 100 years.	Poor - No treatment to reduce toxicity, mobility, or volume, although natural decay of cesium-137 would reduce concentrations to background in approximately 100 years.	Poor - No treatment to reduce toxicity, mobility, or volume, although natural decay of cesium-137 would reduce concentrations to background in approximately 100 years.

a. NA = Not applicable.

A.3 Conclusions Regarding Potential Remedial Actions for L-Lake

Based on the preliminary options analysis summarized in Section A.2, institutional control or possibly no action may be the most appropriate remedial option for areas of contaminated lake-bottom sediments above the stream channel and floodplain areas that would be eventually exposed if the lake was drained. Remediation options for the contaminated stream channel and floodplain currently submerged in the lake were not examined in the preliminary remedial options analysis, but would be considered as part of the Steel Creek IOU, which is similarly contaminated. L10-04

DOE recognizes that draining L-Lake under the alternatives it is considering in this EIS would change the nature but not the range of remedial options available for exposed contamination in the stream channel, floodplain, and other lake bottom areas from those currently available (i.e., with the lake intact). For example, the risk posed by exposed contaminated sediments would have to be considered under any option in which the lake was drained, and such parameters as control of woody vegetation on exposed areas and the feasibility and cost of refilling the lake (e.g., to reduce risk to acceptable levels by natural decay of radionuclides) are likely to be important parameters that would be of little or no concern if L-Lake remained intact.

However, DOE is coordinating with EPA and SCDHEC as necessary to ensure that decisions it makes with respect to the River Water System in this EIS are compatible with potential remedial decisions to be made for L-Lake under the FFA. As appropriate, DOE will document in a mitigation action plan actions it would have to take to ensure this compatibility in the interim between issuance of a Record of Decision for this EIS and issuance of remedial decisions under the FFA. TC

A.4 REFERENCES

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